MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

EME3206 – CONTROL ENGINEERING

(ME)

26 MAY 2017
3.00 p.m. - 5.00 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages including cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

4. Table of Transform pairs has been included in Appendix.

Question 1

(a) A simplified version of the suspension system of an automobile is shown in Figure Q1 (a). Assuming that the motion $u(t)$ is the input to the system and the motions $x(t)$ and $y(t)$ are its outputs, drive the dynamic model of the system. Obtain Laplace transformations of the model equations, assuming zero-initial-conditions. Draw the block digram relating the output $Y(s)$ to the input $U(s)$.

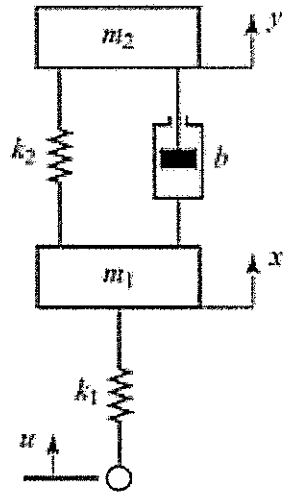

Figure Q1 (a). A simplified model of a suspension system of an automobile

[15 marks]

(b) For the signal flow graph of a system shown in Figure Q1 (b), Apply Mason's gain formula to obtain the closed loop transfer function $\frac{C(s)}{R(s)}$.

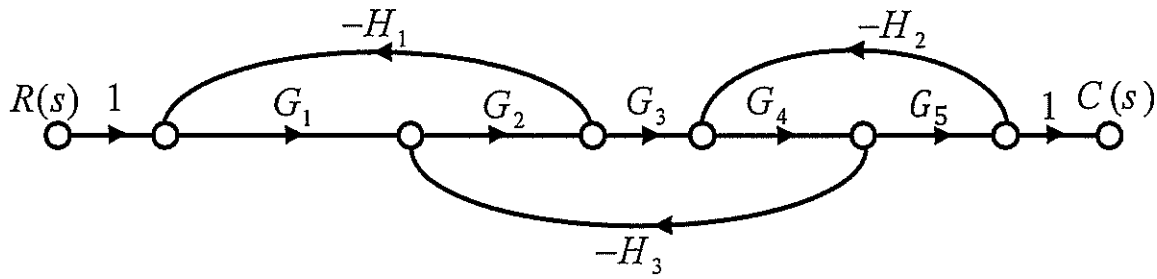

Figure Q1 (b). A signal flow graph of a system

[10 marks]

Continued...

Question 2

(a) A second order system has an undamped natural frequency, ω_n, of 12 rad/s, the damping ratio, ξ, of 0.2 and a gain, K, of 1.

(i) Derive the transfer function of the system, $\frac{C(s)}{R(s)}$,

(ii) Given that the sytem is excited with a unit step input, find the times of the first and second peaks, t_{p1}, t_{p2}, the setling time, t_s, and the maximum overshoot, M_p.

(iii)Using the found values in (ii), sketch the unit step reponse of the system, $c(t)$.

[4 + 9 + 4 marks]

(b) The open loop transfer function of a unity feedback system is

$$KG(s)H(s) = \frac{10}{s+20},$$

When the system is subjected to a unit step input, calculate:

(i) The position error constant, k_p, and

(ii) The steady state error, e_{ss}.

[4 + 4 marks]

Continued...

Question 3

(a) A feedback system with a proportional controller is shown in Fig. Q3 (a).

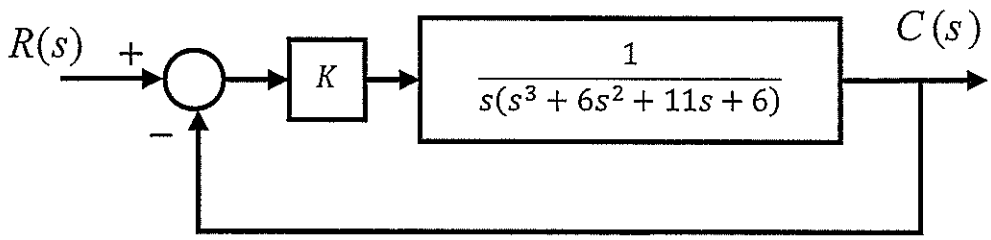

Figure Q3 (a). A feedback system with a proortional controller

(i) Apply Routh-Hurwitz Criterion to determine the range of values of K for the feedback system to be stable.

(ii) Find the value of K that will cause sustained oscillations in the system response and the frequency of oscillation.

[7 + 3 marks]

(b) A feedback control system is shown in Figure Q3 (b). If $K = 1$:

(i) Draw the Bode diagram for the system (with magnitude as asymptotic lines),

(ii) From Bode plot, determine the approximate values of phase and gain margins,

(iii) From the plot, determine the value of K for critical stability.

[*All necessary steps of Bode diagram drawing including phase calculations must be shown*].

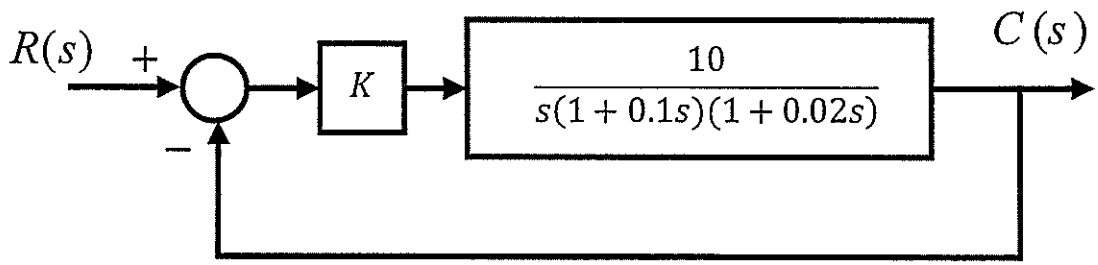

Figure Q3 (b). A feedback control system

[8 + 4 + 3 marks]

Continued...

Question 4

(a) A feedback control system with a proportional controller is shown in Figure Q4 (a).

(i) Sketch the root locus of the system,

(ii) Design the proportional controller (choose the value of K) such that the damping ratio does not exceed 0.5 and the time constant is less than 1 second.

[*All necessary steps of root locus construction and controller design must be shown*].

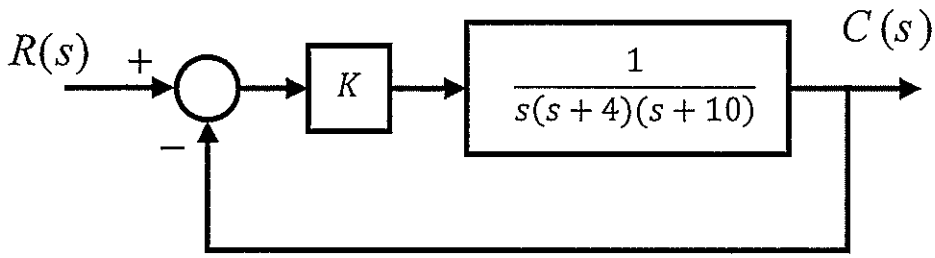

Figure Q4 (a). A feedback control system

[11 + 4 marks]

(b) Consider the system described by the differential equation,

$$\dddot{y} + 3\ddot{y} + 2\dot{y} = u$$

(i) Derive a state space representation of the system,

(ii) Construct its state diagram.

[6 +4 marks]

Continued...

Appendix – Laplace Transform Pairs

f(t)	F(s)
Unit impulse δ (t)	1
Unit step u(t)	$\frac{1}{s}$
t	$\frac{1}{s^2}$
$\frac{t^{n-1}}{(n-1)!}$ (n = 1, 2, 3, …)	$\frac{1}{s^n}$
t^n (n = 1, 2, 3, …)	$\frac{n!}{s^{n+1}}$
e^{-at}	$\frac{1}{s+a}$
te^{-at}	$\frac{1}{(s+a)^2}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$e^{-at} \sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$
$1 - \cos \omega t$	$\frac{\omega^2}{s(s^2+\omega^2)}$
$\omega t - \sin \omega t$	$\frac{\omega^3}{s^2(s^2+\omega^2)}$
$\sin \omega t - \omega t \cos \omega t$	$\frac{2\omega^3}{(s^2+\omega^2)^2}$
$\frac{1}{2\omega} t \sin \omega t$	$\frac{s}{(s^2+\omega^2)^2}$
$t \cos \omega t$	$\frac{s^2-\omega^2}{(s^2+\omega^2)^2}$

End of paper